Climate Change and the Implications for Forest Fires in British Columbia

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Abstract

British Columbia has engaged in fire suppression techniques since 1912 (British Columbia Forest Service, 2010). As a result large amounts of fuel build-up have resulted in many areas of our forests which must be managed. Climate change is expected to create a number of changes for the characteristics of our environment. These changes will alter how forest fire regimes interact with the landscape and the forest fuels upon them. Forest fire management will need to adapt to the changing fire disturbance regimes and as such I have made the following recommendations:

- More intensive mapping of forest fire disturbance regimes.
- Investigation of new management strategies for forest fuels.
- Utilization of different tactics such as:
    - Prescribed burning
    - Assisted migration
- Practice "Adaptive Management" to provide flexibility against changing future conditions.
- Create Policy guidelines which will assist fuel management operations across the landscape.
- Due to the large role of Carbon emissions in forest fire management, Carbon management should be integrated with fuel management plans.

I believe that these steps will allow fire management in British Columbia to more easily cope with the implications of climate change.

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Introduction

Climate change is a growing problem and presents some potentially serious consequences for the future. With global temperatures expected to rise as a result of climate change, (Stocks, 1993) the consequences for forest fires will likely increase. British Columbia has a history of fire suppression which has allowed fuel build-up to reach dangerous levels in many areas of the Wild land Urban Interface (WUI). This poses a great threat to communities surrounded by forest which don't engage in forest fire management. Growing populations have increased the interaction of the public with the forest and therefore the number of human induced fires. There are many different ecosystems throughout British Columbia which historically experienced forest fires of different frequency, intensity and severity. As climate change alters the fire disturbance regime in these ecosystems, unforeseen reactions could occur. In order to minimize damage to the public, B.C. will need to initiate new strategies to control fires. These strategies will help prepare communities which are inexperienced in dealing with fires. Planning will need to focus on how the climate alters fuel build-up and create tactics pre-emptively. Existing laws and regulation limit the amount of fire prevention methods employed over the landbase in B.C. Policy will need to be reviewed and changed in order to allow for greater fire preparedness and more aggressive firefighting tactics. Climate change will have unknown consequences for the fire season throughout British Columbia and could alter the behaviour of forest fires in many different ways. Forest fires have huge implications for the natural cycle of carbon in our ecosystems. An increase in the frequency, intensity and severity of forest fires will have a large effect on the carbon storage of our ecosystems which will need to be accounted for. Climate

change presents a variety of issues in dealing with changing forest fire behaviour in the future. With public safety at stake we need to develop strategies to minimize the increasing hazard of fires.

I propose to look into the implications of climate change for the danger of forest fires in British Columbia. I believe that this needs to be examined in order to prepare and employ different strategies as soon as possible.

Literature Review

How will ecosystems change in the future?

Climate change not only raises questions concerning the frequency, intensity and severity of forest fires but also how ecosystems will change and react, and the resulting impacts on fires. Focussing our efforts on fuel and climate modelling and mapping will allow us to better understand how things might change in the future. Utilizing these techniques we can minimize the damage to natural cycles, the public and our natural environment. Climate change needs to be combated through the reduction of carbon emissions. Forest fires pose a huge risk for carbon emissions as they can release far greater quantities of carbon than in situations of controlled burning which emulate the natural forest fire regime. The implications of climate change on forest fires needs to be considered in order to protect our communities, climate, and forest values.

The increasing risk of a shift in natural fire regimes poses a threat to the balance of our ecosystems. Climate change is expected to lead to an increase in temperatures (Stocks, 1993) and therefore result in a greater risk of wildfires. One of the largest

factors for concern is that a larger number of extreme fire weather events are expected to occur with changing conditions (Liu et al, 2010). A history of fire suppression combined with warming trends and extended periods of drought will allow for catastrophic fires to occur at a greater frequency. These high intensity events will need to be effectively managed as they have a greater potential for irreparable damage to our natural environment. Liu et al (2010) state that “Climate change that results in drier, warmer climates has the potential to increase fire occurrence and intensify fire behaviour and thus may alter the distribution of fire-dependent, -sensitive and -influenced ecosystems” (p.685). This could create the effect of redistributing the pattern of ecosystems therefore posing a risk to rare and sensitive ecosystems which may be lost in response to the change. As environments shift, different areas could be prone to fires where fires had never occurred previously. Areas such as the high alpine may experience fire as ecosystems shift and these areas become more vegetated. This could have negative consequences for such areas which previously had little to no natural disturbance events. This is just another effect of climate change which would damage or eliminate sensitive and or rare ecosystems. Introducing these new areas into the fire disturbance cycle will increase variability in fuel hazards over the landbase and decrease predictability of fire hazards. A complex relationship between soils, plants and fires allows for a high level of resilience to the natural forest fire regime that the area is accustomed to (Johnstone et al., 2010).

> "However, if fire regimes shift in response to changing climate conditions, fires may interrupt these feedback cycles and cause abrupt shifts in community composition. These changes are most likely to occur in portions of the landscape

> where community composition is not tightly constrained by slow-changing abiotic factors, such as in areas of intermediate moisture drainage." (Johnstone et al., 2010, p. 1310).

This statement concludes that drainage areas may be more susceptible to shifting fire regimes as a result of climate change. As such, drainage areas may be of concern in the future as they often represent a diversity of habitats. Climate change will serve to alter a number of variables in a multitude of ecosystems throughout British Columbia. These changes could have a resounding effect on the cycles which are essential to the proper functioning of the environment, therefore causing unanticipated damage. Natural fire disturbance regimes are an important part of many ecosystems which need to be monitored in order to minimize the effects of climate change.

Fire Season Changes

Climate change is expected to cause disruptions in a variety of weather characteristics which presents implications for forest fire disturbance cycles. As overall temperatures rise (Stocks, 1993), and possibly increase summer drought events, the forest fire season is expected to worsen. “Perhaps the most significant impact we found of climate change on wildfire potential is the lengthening of the fire season, accompanied by an increased likelihood of more extreme weather events” (Liu et al., 2010) (p. 695). The lengthening of the fire season could have a significant impact for many people. It would affect farmers growing crops, forest operators working hours throughout the season, and individuals which may suffer loss of certain recreational

opportunities. This could pose a negative response for the economic benefits associated with the limitations imposed by an extended fire season. Liu et al. (2010) state that “Climate change can affect the number of fires occurring annually, the length of the fire season, the area burned by wildfires, and can increase fire intensity. “The changes in these fire properties mean more frequent and higher intensity of seasonal wildfires and therefore larger fire potential” (Liu et al., 2010, p. 694). This means that there will be a higher probability of extreme fire weather events and an increased threat to public safety. Extreme fire weather events would also present problems as they would generally have a faster rate of spread and would leave less time to be controlled (Fried et al., 2004). In areas with drier climates, the fire season could extend to the point of lasting the entire year (Liu et al, 2010). This would pose problems as it would leave little time for operations dependant on conditions where forest fires aren’t a risk. While many areas of B.C. experience enough of a season shift for this to be a reality in the near future, there are pockets in Southern British which could be susceptible. Wotton, B.M. (1998) states that the “Canadian Climate Centre General Circulation Model (GCM) scenarios suggest an increase in overall fire occurrence of 25% by 2030 and 75% by the end of the century” (p. 253). These scenarios portray a very dramatic sense of how fire intensity, severity and frequency could change in the near future. Although Fried (2004) says that “Ultimately, the effect of climate change on wildfire severity will depend on pre-suppression activities, fire suppression strategies, human settlement patterns, the degree of climate change, and how these affect vegetation type and fuel loading” (p.188). If we do not pay attention to how climates are expected to change,

extreme forest fire events may overwhelm our management capacity and put the public's safety at risk.

Carbon

An increase in forest fire events as well as the degree of damage would subsequently increase the amount of carbon released into the atmosphere. Forest fires not only release carbon, but cause problems for aesthetics, health and release other trace gases into the atmosphere. "Smoke particles are one of the sources of atmospheric aerosols, which affect atmospheric radiative transfer through scattering and absorbing solar radiation and through modifying cloud microphysics. These processes can further modify clouds and precipitation and atmospheric circulation" (Liu et al., 2010, p. 686). Emissions from forest fires could have further negative effects on weather patterns in the area.

As climate change becomes increasingly important, carbon management will as well. Forestry companies may become more heavily relied upon to manage for carbon as markets dictate a higher price. This could create a greater opportunity for forestry in British Columbia as there would be more money available for advanced silvicultural practices which would sequester a greater amount of carbon above the baseline. Carbon markets may also be able to generate money for fuel management which would protect public safety, provide economic stimulus and restore ecosystem help. The key to accessing forest fire prevention resources in British Columbia's future may be the access of carbon markets as the risk of larger fire events increase.

Prescribed burning is a useful fuel management tool that may need to be used on a larger scale in B.C.'s future. It has been shown that prescribed burning releases significantly less carbon into the atmosphere than large, uncontrolled fires which often cause significant environmental damage (Diggins et al., 2010). Prescribed fires can also be used to restore ecosystems which experience fuel build-up and can re-turn them to their natural fire disturbance cycle in a safe and controlled manner. Fire management is extremely important as forest fires are one of the largest sources of carbon emissions in British Columbia and as such must be managed. With the vast amount of forested land that we have in B.C. we must manage it to mitigate the potential effects of the carbon emissions of our forest fires. Uncontrolled, these forest fires could have drastic effects on global atmospheric carbon levels. Stocks et al. (1998) state that warmer and drier conditions resulting from climate change "would likely result in a positive feedback loop between fires in boreal ecosystems and climate change, with more carbon being released from boreal ecosystems than is being stored" (p. 3). This positive feedback loop could have drastic effects by increasing the rate of climate change and the dangers that it presents for forest fires. It is our responsibility to manage the carbon cycle as we have shifted its balance so drastically. Liu, Y. et al (2010) suggest that we can minimize the damage caused by forest fires by limiting carbon emissions through the use of "advanced environmental technologies". Controlling carbon emissions will not only promote environmental stewardship but it will also limit the positive feedback effect of climate change. This effect will consequently exacerbate forest fire conditions and emit even more carbon into the cycle.

What different strategies will need to be employed?

With changing fire disturbance regimes, management strategies will need to be changed accordingly. Fires could occur in areas which have not previously experienced fire and the inhabitants would therefore be unprepared to manage them. Previously unaffected communities could become more susceptible as change occurs especially without fire preparedness plans in place. Research and mapping of climate shifts would help prepare these communities by giving them advance notice of interface fires. Liu et al. (2010) believe that there has been an absence of fire weather data collected throughout time and that the current data is used to extrapolate findings into the future. The method of extrapolating findings from current observations may not be the best strategy in predicting forest fire danger. Prior to human settlement, fires had a more frequent disturbance regime being allowed to burn without human interference. This removed fuel build-up from the landscape leading to a more open forest ecosystem. By creating a better inventory of fire disturbance and how humans have affected it over time we might be able to create more accurate predictions of fire disturbance patterns. Stocks et al. (1998) reiterate this point saying “There is a strong need to continue modelling future climates, using higher-resolution models as they become available, so that future fire management planning can be accomplished in the most informed manner possible” (p.11). Another important aspect of mapping wildfire disturbance would be to identify areas where shifting climates would have the largest impact. Certain areas may be affected more than others due to factors such as types of fuels, amounts of fuels, fuel moisture, climate and spatial fuel continuity. Other, more aggressive strategies may have to be employed to manage our forests for fuel build-up.

Prescribed fire has typically not been used in managing for fires dues to the public perception of adverse health effects, aesthetics, and fear of escaped fires. Under strictly controlled conditions, prescribed fires can be an effective tool for minimizing fuel build-up with minimal to no adverse effects. Filmon et al. (2004) state that “the province should establish strictly controlled conditions for using prescribed burning as a fuel management tool” (p.32). It will become more important in the future to reduce the risk of fuel build-up in areas of the Wildland-urban interface between the urban and forested areas. Strategies such as prescribed burning may have to be relied upon to reduce fuels and increase safety. Existing tactics such as thinning, pruning, brush removal, and fire breaks may still be used but may have to be modified to manage fires efficiently. Managing forest disturbances can be broken down into a number of steps to assist in maximizing forest health and minimizing the restoration time needed (see Table 1). Following these steps can help minimize the initial damage, allow for forests to recover more quickly and increase forest resilience. Each of these steps will require different approaches when dealing with the implications of climate change for forest fire management. Pre-emptively altering the landscape in anticipation of the future fire climate would reduce the risk to ecosystems as well as public safety. This could be done by anticipating climate patterns and planting different tree species in areas which would be better adapted to the shifting fire disturbance regimes. Current firefighting techniques may need to be improved in order to battle a higher number of fires during extreme weather events. Podur et al. (2010) fear that “Fires can be suppressed, but the capacity to suppress fires may be overwhelmed by climate change-driven increases in

fire numbers and intensity" (p.1301). This could stimulate an increase in the quantity of firefighting resources, a shift to using different techniques or a combination of both.

Table 1: Strategies for dealing with disturbance effects.

Managing the system before the disturbance

To reduce vulnerability:

- Altering forest structure (e.g., tree spacing and density, standing dead trees, or coarse woody debris on forest floor)
- Modifying the landscape structure (e.g., the size or location of management activity)
- Changing species composition (e.g., planting alternative species)

To enhance recovery:

- Altering structure (e.g., enhancing advance regeneration)
- Adjusting species composition (e.g., planting alternative tree species)

Managing the disturbance

- To reduce the opportunity for the disturbance to occur (e.g., regulating nonnative species introductions or use of fire)
- To reduce the impact of the disturbance (e.g., rapid response to control insects, pathogens, or fire)

Managing recovery

- To speed recovery (e.g., adding structural diversity, planting late-successional species, or reducing environmental stress)
- To reduce vulnerability to future disturbances (e.g., managing tree density, species composition, forest structure, and location and timing of management activities)

Monitoring for adaptive management

- To measure the state of the forest with and without disturbance
- To determine interactions between disturbances

Source: Dale et al. "Climate Change and Forest Disturbances." *Bioscience* 51.9 (2001): 723-34.

As our natural environment shifts, we must be flexible in management decisions and create strategies which will provide the best outcomes for the values of the landbase. Education can also be highly influential for forest fire management in the future. With an increased risk for the intensity and quantity of fires in the future, (Liu et al., 2010) it is important to ensure the public is knowledgeable about human-caused fires especially through the dry summer months. Rising populations will expand current city limits along with the Wildland-urban interface. This will lead to an increased number

of human interactions with forested areas and therefore an increased potential of human-induced forest fires.

Existing forest fire management strategies will need to be improved in order to maintain public safety and ecological health. Policy change would allow different fire management strategies to arise which could be more efficient in dealing with climate change variables.

Policy Change

Climate change will alter how we need to interact with the forest in regards to fire management. Government policy regulating these management activities may need to be altered in order to achieve the best outcomes for our ecosystems. Policy decisions are often made in regards to public perception on a certain issue and will need to be swayed before positive change can be made.

> "Within several provinces (Saskatchewan, Manitoba, Ontario, Quebec), the area under fire management is broken up into full suppression zones and observation zones. In the former, policy states that all fires are actively suppressed. In the latter, fires are generally monitored and suppressed only if a fire threatens human values (e.g. lives and property in a northern community or infrastructure supporting northern communities)" (Wotton et al., 2010, p.257).

This quote from Wotton et al. represents the idea that not all forest fires require suppression. Some provinces allow areas which afford no threat to public safety, to burn freely. This policy allows for fuels to be naturally reduced through the fire disturbance regime for the area.

Since British Columbia has engaged in fuel suppression since 1912 (British Columbia Forest Service, 2010), forest fuels have increased to dangerous levels in a multitude of ecosystems across the province. This unnatural state will only become exacerbated by climate change if the trend of suppression continues. Policy is often determined by the values held by the public. A shift in these values may allow for a revision of burn policy in B.C. if the public realizes the value of fire as a natural process (Dale, V.H., 2001). By following the policy decisions of these other provinces; B.C. could cut down on management costs, reduce fuel build-up and restore the natural fire regime of a variety of diverse ecosystems. Furthermore, revision of government policy in forest management could determine the feasibility of certain fire management strategies or even promote them.

Filmon et al. (2004) state that “the addition of stumpage to the basic cost of harvest often negates the economic viability of operating in low-quality tree stand areas” (p. 32). By amending stumpage prices for low quality timber, companies would have an economic incentive to harvest low quality stands. Excluding volumes from the Annual Allowable Cut (AAC) which operate under fuel management guidelines would allow

areas to pursue management activities more aggressively (Filmon et al., 2004)(Le Goff, H, 2009). A larger number of high risk areas could viably be managed to reduce the fuel hazard around communities. Filmon et al. (2004) also recommend that an auction based stumpage pricing system should be used instead of the current system. This change would allow for more opportunities for fire management strategies to occur over the landbase.

Policy should be enacted in ways to increase public safety by using strict requirements especially in areas of the Wildland-urban interface (Filmon et al., 2004). Land-use policy may be needed in the future due to an increase danger of severe wildfires. An extended fire season may force the government to create more strict guidelines for both public and private lands. Forest fire preparedness plans are an important aspect of community safety. Filmon et al. (2004) mention that “As is the case for municipal governments, regional districts should be required through legislation to provide local emergency plans developed to a provincial standard and maintained to a current status” (p. 71)**.** This will prove more important as fire risk increases with changing climates (Liu et al., 2010) and forest fire preparedness plans will need to be revised accordingly. Government policy is important as it protects the values and safety of the public. Policy must be revised as climate change increases the hazard of forest fires and the subsequent danger to the public.

Discussion

The impending changes to the fire season in British Columbia will force us to approach fire management from a different perspective. Ecosystems are expected to shift as temperatures increase forcing the boundaries to move into new areas (Liu et al., 2010). Mapping of fire disturbance and climate patterns could possibly help to recognise where these shifts could occur in the future. Forest managers may be able to limit ecosystem damage by pre-emptively planting different species which may thrive in expected future conditions. This assisted ecosystem migration would allow areas to adapted to change more easily as essential processes might not be as negatively disrupted. “Adaptive management” is an important idea which must be used in future fire management. This would be employed by using flexible fire management strategies which would adapt in relation to the changing fire disturbance events. I believe that more aggressive tactics may have to be used in order to protect the public. Prescribed burning should be used more widely as a fire management tool to decrease fuel loading. Public perceptions of the risks often minimize or eliminate the use of fire in proximity to communities. Education may allow the public to see the prescribed fires can be a highly valuable tool when used in strictly controlled conditions. In depth fire weather documentation will allow us to more accurately predict events in collaboration with intensive field observations. British Columbia will need to revise government policy regarding forest fire management in order to increase the efficiency management strategies. Filmon et al. (2004) provide very good policy recommendations for establishing better fire management skills throughout British Columbia. I believe that the realization that not all fires require suppression is an important attribute of government

policy. Education may help to introduce this idea to the public as a healthy part of many ecosystem functions. Mountain pine beetle killed timber is a huge problem for B.C. as it represents a fire risk over a vast area of the landscape. Policy must be used to remove dead timber such as this from the AAC so that we can minimize this large amount of fuel build-up. Changes to the fire season could have severe economic, social and environmental implications for B.C. It will be important for us to increase fire management capacity, in order to minimize the amount of large, uncontrollable, fire weather events that may cause irreparable damage. Carbon management is becoming an increasingly important tool as the consequences of climate change are comprehended. Carbon markets may become a valuable asset to accessing money for fire management operations. Removal of fuel build-up, pruning, thinning or other advanced silvicultural techniques could be executed through carbon offsetting developments. Climate change will introduce an unprecedented amount of unpredictability to fire management in the future. It is British Columbia's responsibility to protect the vast amount of forested land that we have. Developing our fire management techniques as climate change alters our natural fire disturbance regime will minimize environmental damage as well as the threat to public safety.

Conclusion and Recommendations

Forest fire regimes in British Columbia are expected to change as climate change alters the conditions of our natural environment. Rising temperatures and drying trends could lead to lower fuel moisture, hotter summer conditions, and therefore an increase in the intensity, frequency and severity of forest fires. These conditions combined with fire disturbance events will alter the landscape causing ecosystems to

shift into new areas. Rare and undisturbed ecosystems may be damaged or lost to severe wildfires as a result of these heightened fire season characteristics. In order to minimize the effects of these damaging wildfires we must explore improved management strategies to protect the public's safety. Current fire management tactics may not have the same effects in the future as extreme fire weather events become more common. These increasingly larger fires could have the potential to overwhelm our current fire management capacity. Government policy will need to change to account for fire management tactics over the landbase. Certain regulations are currently too restrictive and need to be modified in order to increase the effectiveness of species management strategies. Climate change will modify the current characteristics of our natural fire season. These changed attributes of the fire season will have resounding effects on a variety of groups. Carbon emissions management is playing an increasingly larger role as the impacts of climate change are becoming gradually more recognized. Wildfires in British Columbia are one of the greatest sources of carbon in the world and must be minimized to decrease environmental damage. Fires are only expected to increase in numbers, frequency, intensity, and severity which will have repercussions for the amount of carbon emitted each fire season. Over time the emissions of these fire seasons could contribute to a positive feedback cycle which would accelerate global warming thus increasing the volatility of the fire season. Due to the multitude of problems that I have suggested that British Columbia may face in the future, I have created the following recommendations:

- More intensive mapping of forest fire disturbance regimes.
- Investigation of new management strategies for forest fuels.

- Utilization of different tactics such as:
    - Prescribed burning
    - Assisted migration
- Practice "Adaptive Management" to provide flexibility against changing future conditions.
- Create Policy guidelines which will assist fuel management operations across the landscape.
- Due to the large role of Carbon emissions in forest fire management, Carbon management should be integrated with fuel management plans.

Climate change is modifying our natural environment and intensifying the conditions which lead to a higher number of extreme fire weather events. British Columbia must take steps to minimize the effects of increasingly dangerous forest fire conditions and protect the public's wellbeing.

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